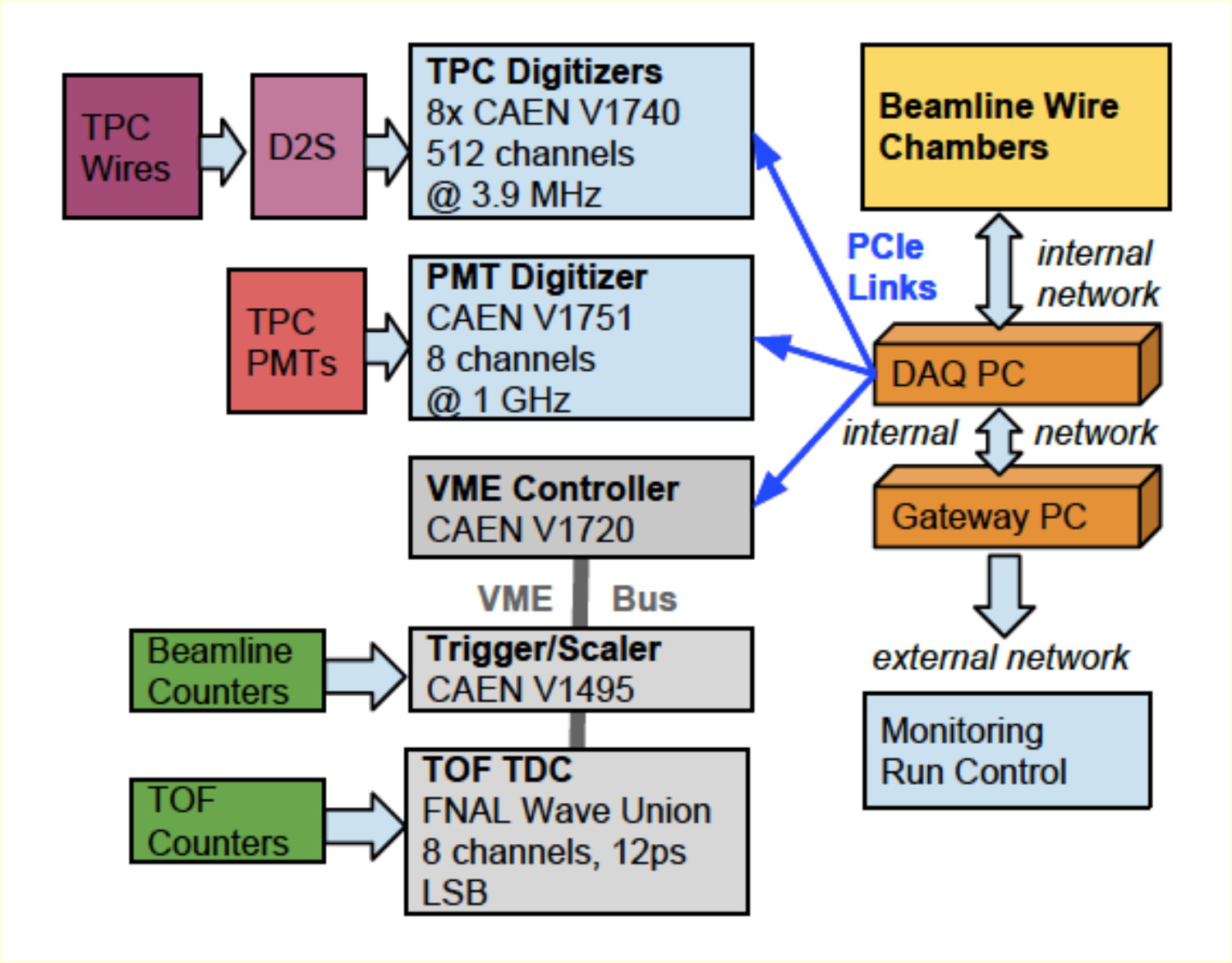
LArIAT Data Acquisition Status

Reading out the LArIAT TPC and associated detectors and how we do so

LArIAT Data Flow



LArIAT Electronics Ensemble, MC-7

PMT NIM Logic Racks

Not yet powered

DAQ Computer and VME Racks

Already ORCed!

LArIAT DAQ Computer & VME Racks MC-7

1 Smoke Detector

CAMAC VME Reset

Monitor+Keyboard

Rack Protect +
Power Distribution

DAQ Computers

1 Smoke Detector

V1740 TPC Wiener
VME Crate

Rack Protect +
Power Distribution

Trigger, Reset,
Gate NIM Fanouts

V1495,V2718,
V1751, WUT
CAENW VME Crate
Trigger + PMTs

LArIAT DAQ Computer & VME Racks MC-7

Two DAQ racks are installed and running in MC-7

- Passed ORC with one caveat for running power cords
- Both racks with smoke and heat protection
  - Two smoke detectors per rack
  - Automatic power off via Rack Protection system
  - Emergency off via “Pulizzi” box
- Power Distribution Unit is remotely controlled via web interface – all devices power-cyclable outside enclosure
- CAMAC crate provides remote VME bus reset for two crates
  - Wiener USB controller – easy to use
  - Easy to do from command line “lariatReset 0 1”
  - Can host future expansion CAMAC cards
- Note that ANY changes at all must be ORC reviewed prior to unattended running
- One remainder to pass ORC: Jinyuan Wave Union TDC (WUT)
  - ToF timing; underground ORC updates today

LArIAT Racks MC-7 Caution

Will fix next long open access

LArIAT DAQ Status TPC Readout

Primary Readout of TPC via CAEN V1740 Wave Form Digitizers

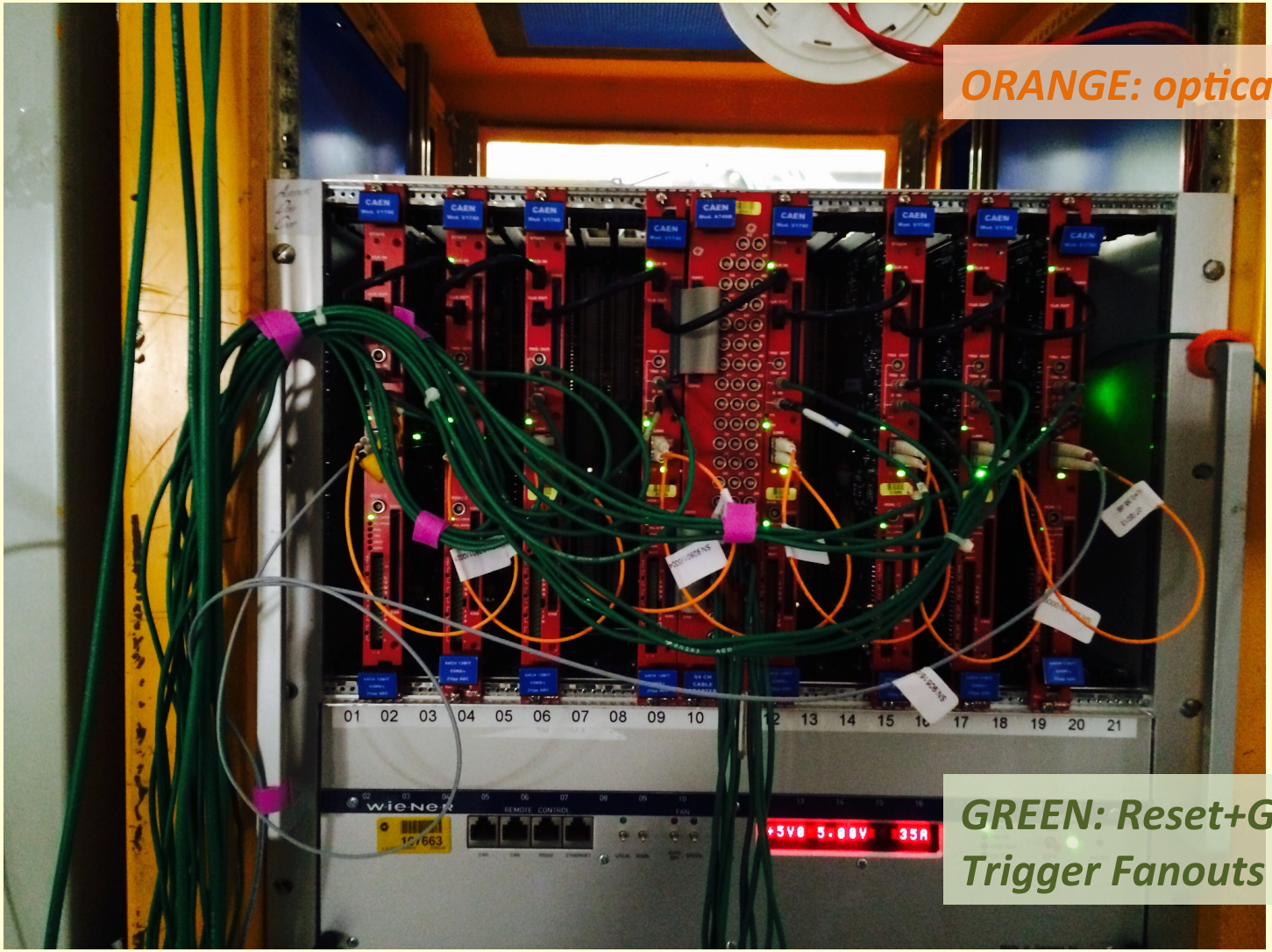
- 64 channels per card
- 480 TPC channels ⇒ 8 cards with 32 spare channels
- 8 operating + 1 spare in hand at MC-7
- Natural operation frequency 62.5 MHz, too high sample rate
  - Cannot reasonably change this frequency (!!!)
- Have "decimation" to reduce the sampling rate by 2^n
  - Achieved by averaging counts in firmware
- Will operate at 256 *ns* sampling period, n=8
  - Total of 1536 samples per trigger, adjustable
  - Optionally 512 *ns*
- One trigger generates 8 × 64 × 1536 × 2 = 1.5 Mb
- Maximum trigger rate per 4.2 second spill ~ 100
- 152 Mb per spill + headers + wire chambers + PMTs
- Challenging rate for a simple system

LArIAT DAQ Status TPC Readout, Part 2

More about V1740s:

- Readout of CAEN proceeds via daisy-chained optical link
- 62.5 MHz Clock generated internally by "Master"
  - Daisy chained to "slaves" requiring time-in (done, painful)
- Link controlled by PCIe card in Linux computer
- Per trigger, typically 90 ± 20 *ms* for *total* readout from board setup + optical transfer + PCI bus transfer into system memory
- Too slow for real-time trigger rate
- ***But*** CAEN V1740 has deep memory that can hold ~120 events before losing triggers
- Readout can proceed leisurely during the 56 second inter-spill period
- CRITICAL: Timer reset must be common and in synch with all other LArIAT readout
- Testing with fake TPC pulses… (see following)

TPC Readout Wiener Crate



GREY: Optical to PCIe card

BLACK: LVDS Clock chain

LArIAT Readout Software

Readout Software factored into two major versions

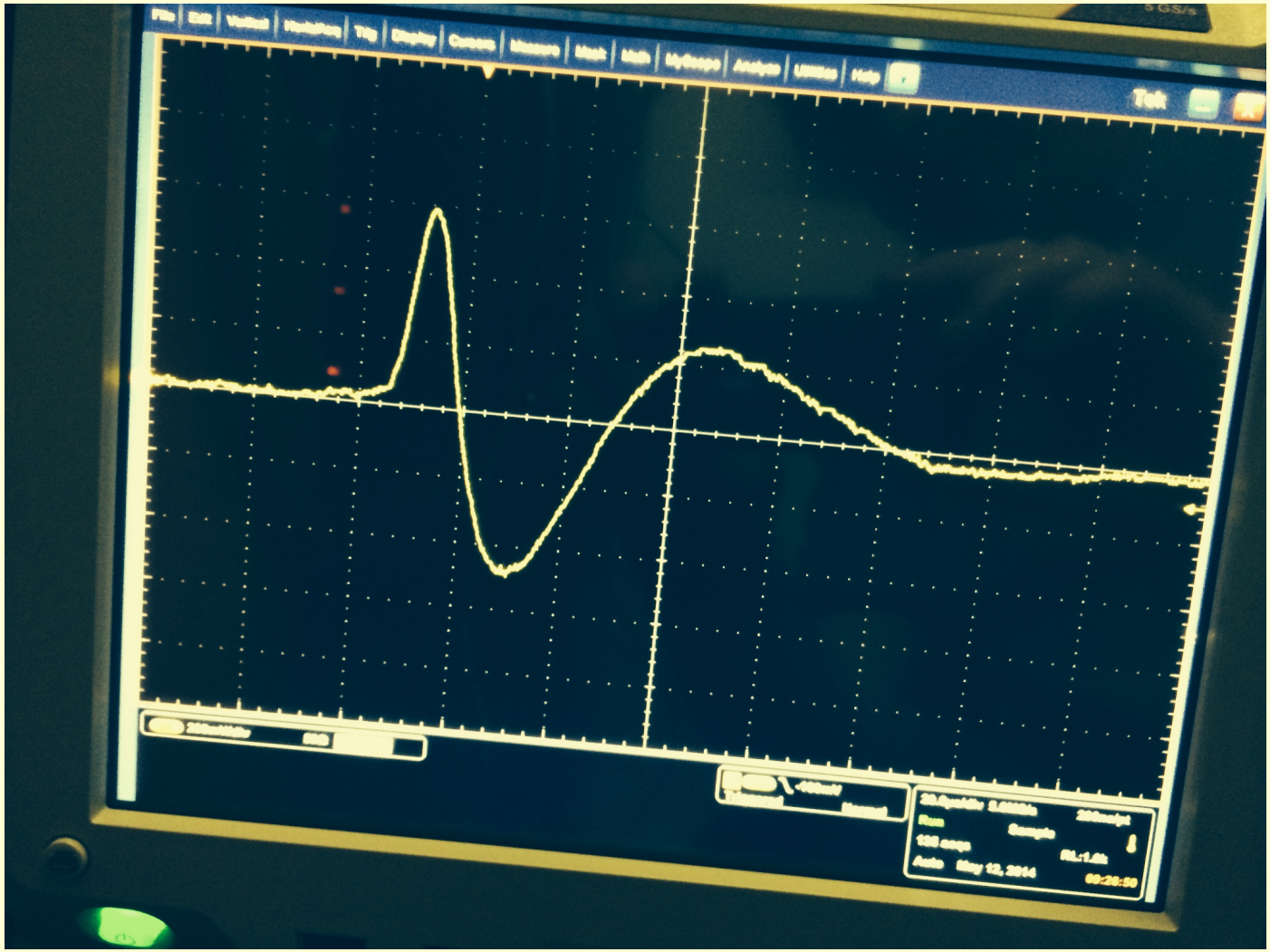
- LariatReadout version 1.0, to be ready from Day Zero
  - Define simple binary data classes, all cards
  - Use configuration control XML text file
  - Implement low-level readout drivers to configure and readout all cards
  - Write to local disk once per spill
  - Essentially complete, modulo some more validation
- Lariat+ArtDaq version 2.0, to be ready longer term
  - Incorporate above into ArtDaq framework
  - ArtDaq builds events, packages into Art objects
  - Serves to real-time online monitor
  - J.Freeman*, K.Biery, R.Rechenmacher
  - *Expect to be ready for first data taking*

LArIAT Readout Event Format, Timing

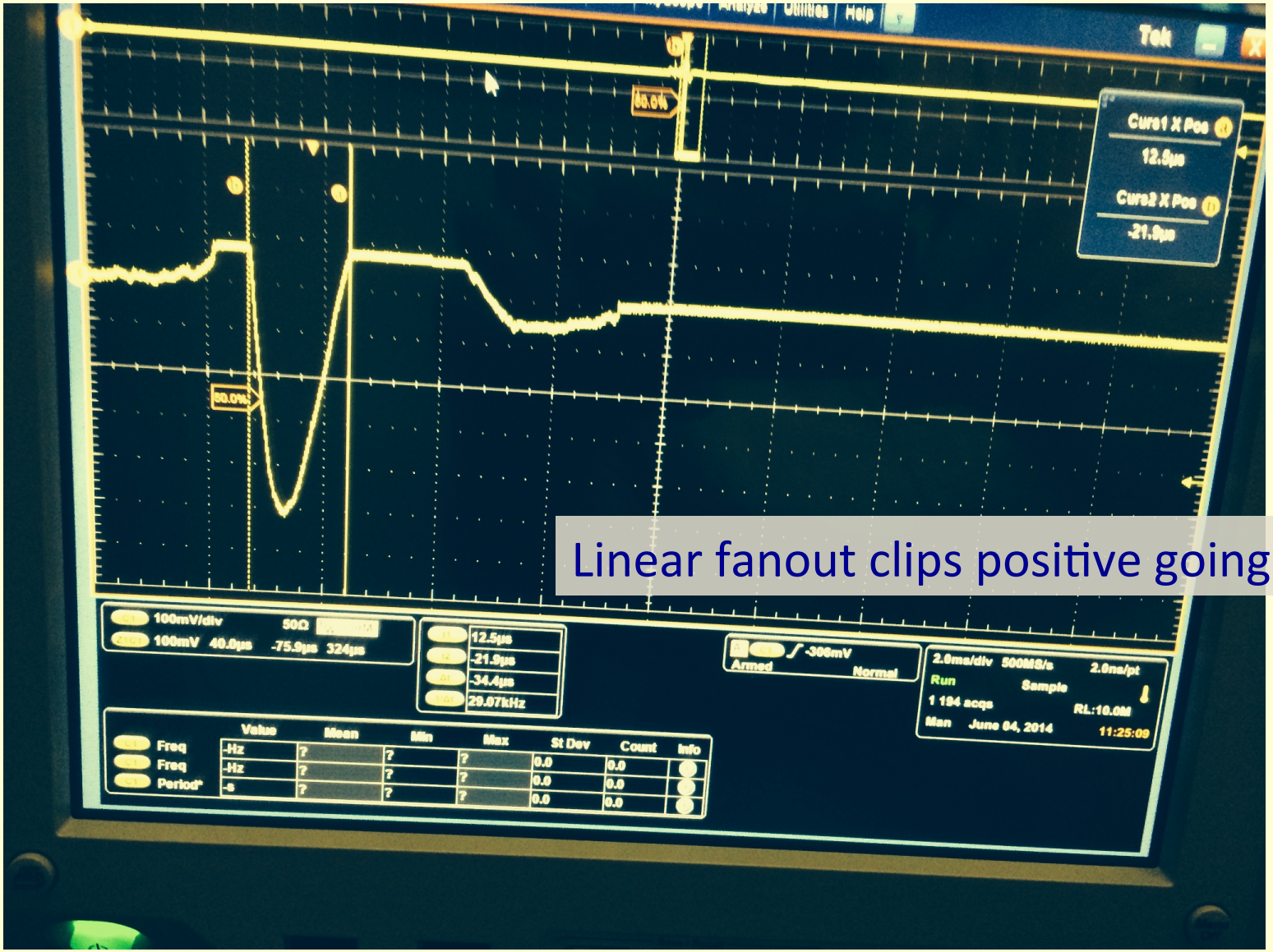
Raw data format defined in lariat-online/daq/include (GIT repository) fragment header files

- Essential "event" of Lariat will be one ***Spill***
- Different cards receive different triggers and different clocks
  - TDCs will receive more "fast" triggers and run in continuous mode
  - TPC fewer "slow" triggers after veto applied; V1740s run in triggered mode
- Ergo, cannot have simple trigger/event definition
- Critical that all cards use common synchronized spill start
  - TCLK $21 = Start of slow Main Injector spill to switch yard
  - End of spill $26 triggers readout and defines spill boundary
  - Allow gate on V1740s for cosmics thru to $00 (MI ramp)
- Common and reliable time reference allows data correlations
- All cards support > 4.2 second coarse time window
- Expect / hope time drift over spill time is negligible

TPC Sample Bipolar Wave Form

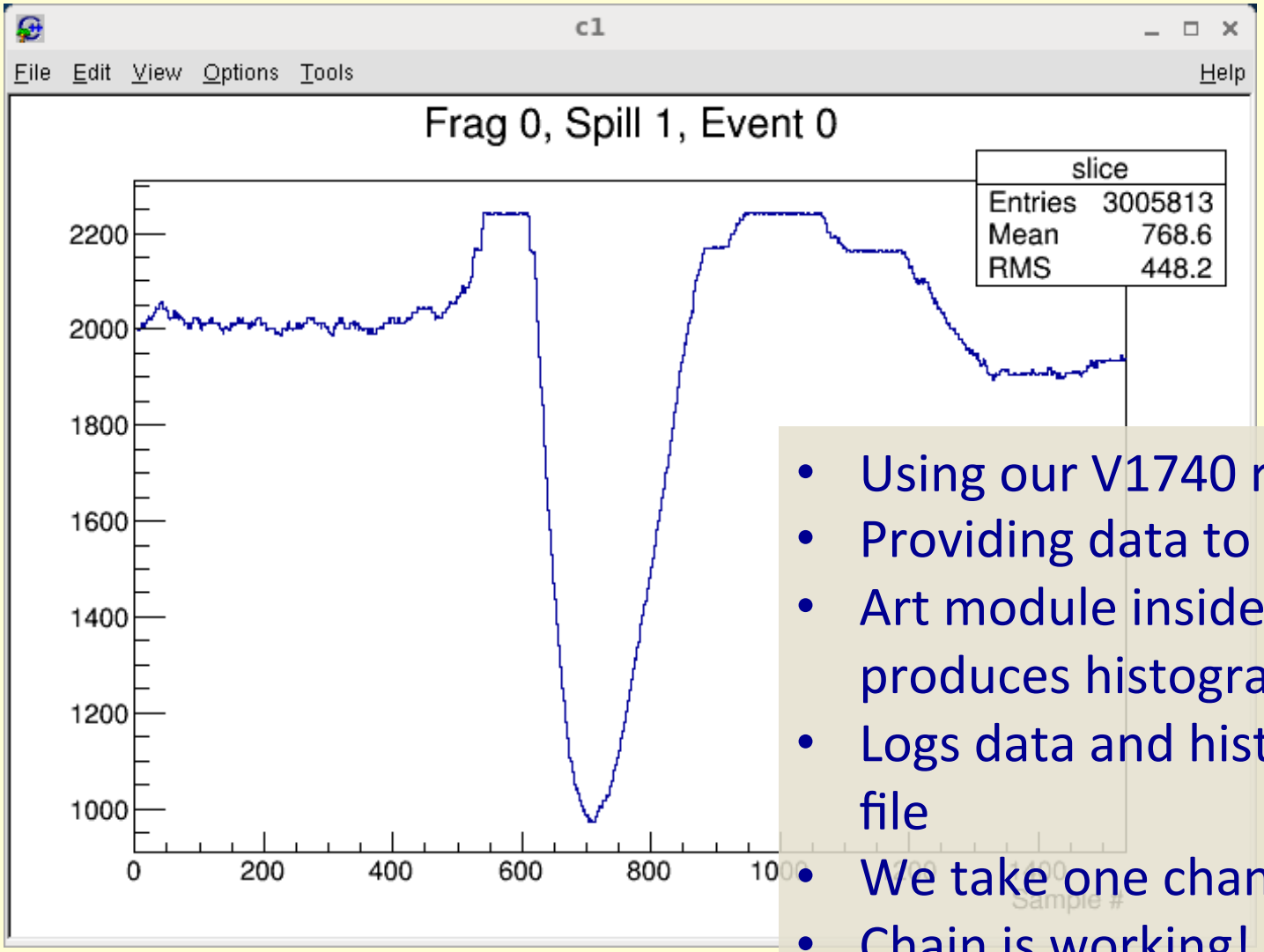


TPC Wave Form Thru Fanout



Linear fanout clips positive going signals

TPC Wave Form Reproduced by our DAQ



- Using our V1740 readout drivers
- Providing data to ArtDaq
- Art module inside ArtDaq produces histograms
- Logs data and histos to Art/Root file
- We take one channel slice
- Chain is working!

LArIAT DAQ – Wire Chambers

- MC-7 Wire Chambers Readout
  - Four chambers fully instrumented with TDCs and controller
  - Runs at 53 MHz, approx 1.2 *ns* per count
  - ftbfwc02.fnal.gov is controller
  - Short runs with new DAQ are working
  - Ample error checking
  - Lariat data fragments designed, first tests OK; need more exhaustive validation
- Expecting to take tertiary beam data with next beam time
- Considered part of test beam facility infrastructure
  - During beam commissioning, under control of A/D

LArIAT DAQ – PMTs

- Lariat has several different PMTs and SiPMs
  - Cosmic muons, veto, TPC, ToF, eight channels
- Readout both time and pulse height
- Time: Jinyuan Wave Union TDC (WUT)
  - Has 12.5 *psec* per time count
  - Jinyuan did quick & dirty resolution measurement ~80 *ps*
  - With 56 bits of time can run days
  - Double buffered allows dead-timeless running
  - At maximum rates > 100 per spill, may have to read out during spill, maximum ~ 2 *ms* per buffer
  - Brand new card (!) – several debugging iterations with JY
- Pulse height: CAEN V1751
  - 1 GHz wave form digitizer
  - Needs integration into Lariat DAQ, partially done

LArIAT DAQ News

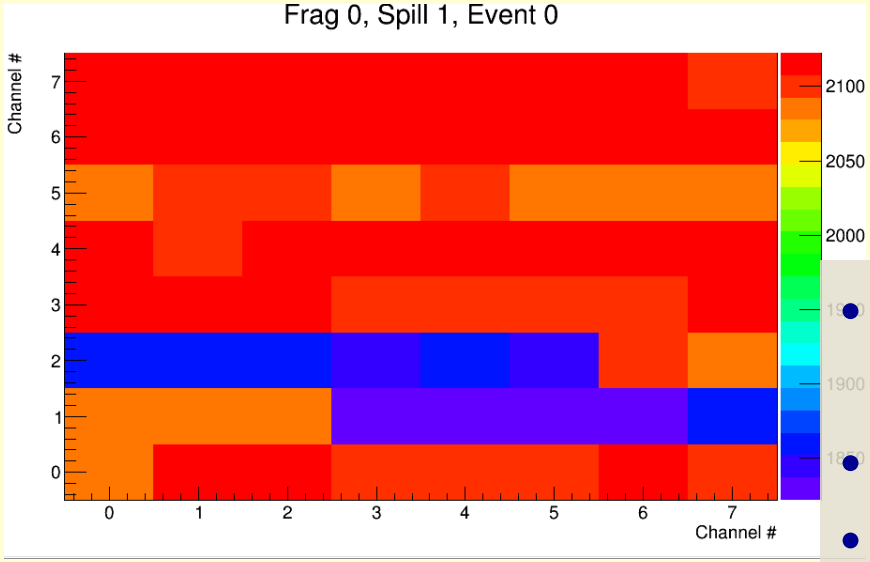
- Have successfully run with:
  - Eight V1740s
  - One Jinyuan WUT
  - Sixteen Sten W/C TDCs in MC-7
  - One V1495
  - One V2718
- Only have V1751 left

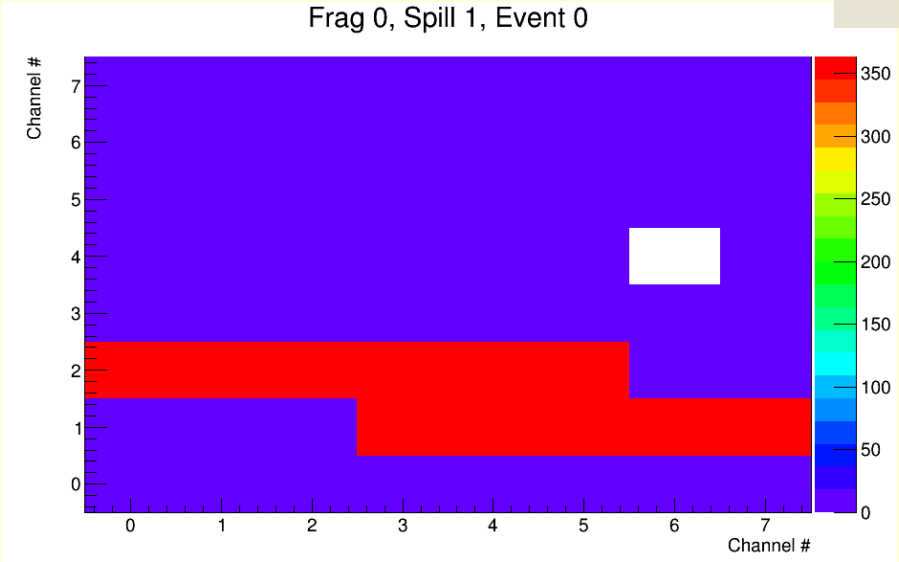
- One major concern:
  - Stability of CAEN V1740 not optimal
  - ~ 24 hour run had several hang ups requiring automated VME bus reset
  - Sometimes require “massaging”
  - Hope for stability when no one is touching hardware

LArIAT Online Monitoring

- Implementing Art module (Pawel Kryczynski)
  - Running within the Lariat artdaq framework
  - For TPC CAEN V1740 ADC data:
    - Pedestal with mean and RMS (simple algorithm)
    - Hit occupancy when ADC over or under threshold
    - Defining pulse definition (uni, bipolar) occupancy
    - Simple wave form event display (in progress)
  - Wire chamber TDC
    - Decoding data structure into 1D histograms, in *x* and *y* direction
    - Implementing *(x,y)* 2D histogram, time bin will be flexible, 2 to 3 counts
  - PMT WUT TDC
    - Need data

LArIAT Online Monitoring, Pedestals

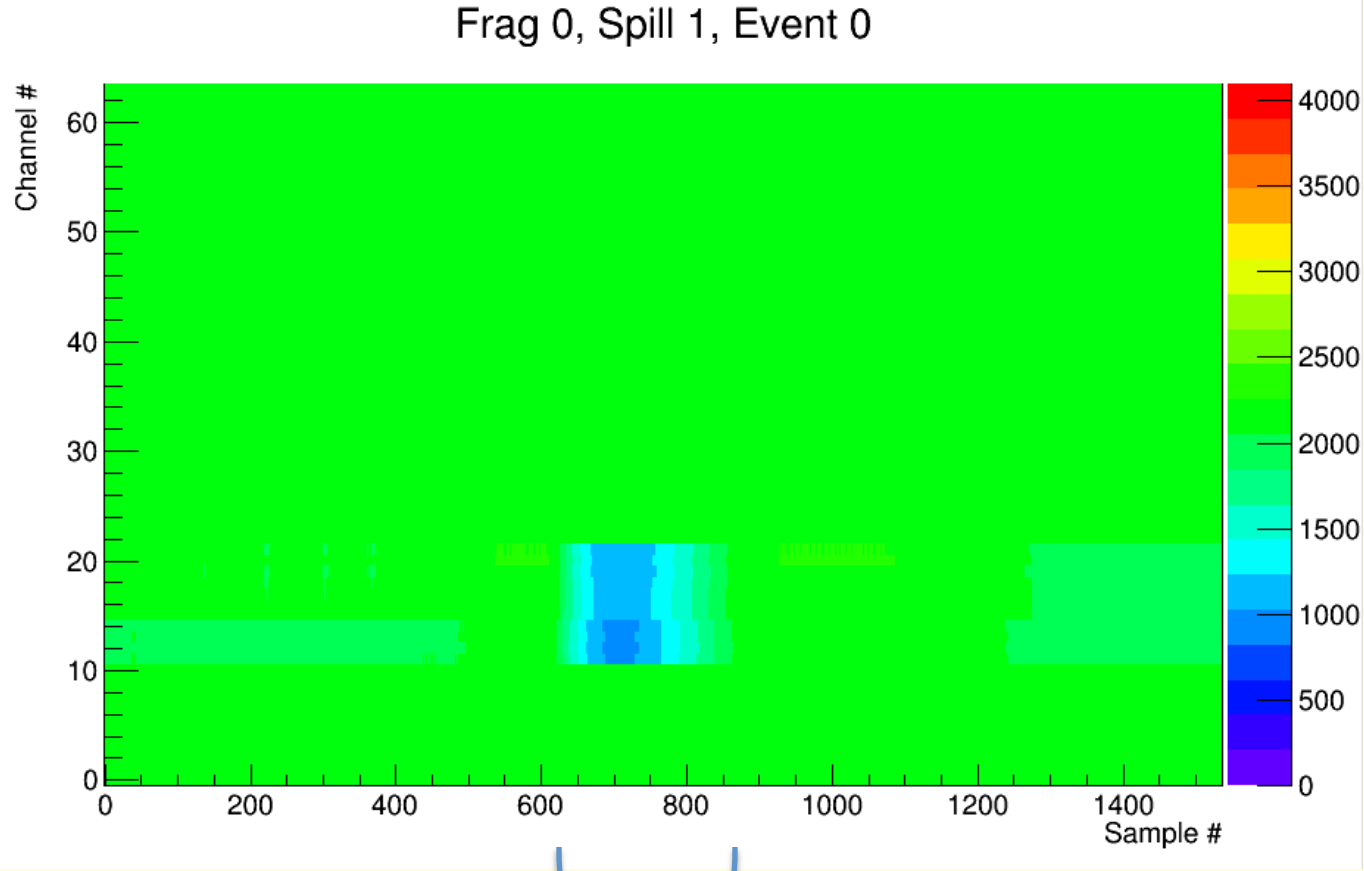




- Pedestals Mean (top) and RMS (bottom)
- Pulser was running during run
- Linear fanout distorts signals

} Channels with continuous pulser

LArIAT Online Monitoring, Wave Form



Low going fake TPC pulse duplicated with Lecroy Linear fanout across several input channels

time, 256 *ns* per count

LArIAT ACnet Monitoring

- IFbeam is the official method for accessing and storing Acnet data for Intensity Frontier experiment
- Real-time or historical
  - For long term storage, we create a “collector bundle” – a collection of ACnet devices to store long term
  - Historical data can be accessed via Web or API
- Two MCenter bundles defined:
  - MCenter_MidSpill
    - Snapshot at $21 plus two seconds
    - Middle of 4 second spill time
    - Magnet currents, temperatures, …
  - Mcenter_EndSPill
    - Snapshot at $36, end of spill plus few milliseconds
    - Spill counters, integrated beam intensities, …
- Favorite device? Easy to add, let me know

  http://dbweb0.fnal.gov/ifbeam/app/GUI/index